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EXAMINER	
QUINLAN, RONALD A	

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4132	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)
	10/587,178	MORIGUCHI ET AL.
	Examiner	**Art Unit**
	Ronald A. Quinlan	4132

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-32_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _1-32_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on _25 July 2006_ is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _07/25/2006 and 11/21/2006_.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Claim Objections

1. Claim 6 is objected to because of the following informalities: the first word of the claim is “he” and should read “The”. Appropriate correction is required.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 3, 9, 16, and 26 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

4. Claims 3, 9, 16 and 26 recite the limitation "said compressive stress" in line 3 of each claim. There is insufficient antecedent basis for this limitation in the claim.

5. It is unclear as to whether the phrase “said compressive stress” is referring to the compressive stress at the surface of the coated film, at one of the intermediate points in the film, at the substrate/film interface, the area between the surface and the intermediate point, or the entire film and therefore renders the claims indefinite.

Claim Rejections - 35 USC § 102

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. Claims 1 and 8-22 are rejected under 35 U.S.C. 102(b) as being anticipated by US 6,066,399 to Hirano et al., hereinafter referred to as “Hirano”, as evidenced by Sheeja et al., *Tribological properties and adhesive strength of DLC coatings prepared under different substrate bias voltages*, Wear 249 (2001), pg. 433-439, hereinafter referred to as “Sheeja” and Materials Science of Thin Films, Deposition and Structure, Milton Ohring, 2nd Ed., 2004, hereinafter referred to as "Ohring”.

8. In regard to Claim 1, Hirano teaches a hard carbon thin film as a protective coating on blades such as razor blades (col. 1, lines 12-21). Hirano teaches the hard carbon thin film as being formed on a base material (col. 2, lines 6-9) and a hardness and internal stress gradient through the carbon layer which serves as the outermost layer on the base material (col. 8, line 60 - col. 9, line 2). Hirano further teaches an example (col. 13, Example 4) in which the carbon thin film has a graded structure in which the sp^2/sp^3 ratio once decreases from a substrate/film interface to a minimum at an intermediate thickness of the thin film, and then increases therefrom toward a surface of the thin film (col. 13, lines 6-10 and Figure 5). Hirano teaches that the sp^2/sp^3 ratio is related to hardness and internal stress in the layers (col. 8, line 60 - col. 9, line 2).

9. Hirano further teaches that ion species, associated with formation of the thin film, in a plasma are varied in kinetic energy with film-forming time, so that the sp^2/sp^3 ratio in the hard carbon thin film is varied in its thickness direction, and that in order to vary the kinetic energies of those ion species, an acceleration voltage may be applied to them (col. 3, lines 35-40). Hirano also teaches utilizing different acceleration voltages to

change the sp^2/sp^3 ratio at the surface of the film and throughout the thickness of the film. Hirano teaches one example of starting the voltage at 2000 V during the beginning of film growth, lowering the voltage to approximately 200 V at some intermediate point, then returning the voltage to 2000 V (col. 13, Example 4, lines 19-33, Figure 13). Hirano does not expressly explain that that high internal stress associated with the low sp^2/sp^3 ratio is compressive stress.

10. However, Sheeja discloses deposition of a high-hardness carbon film under different substrate bias voltages. Sheeja shows that compressive stresses are formed in hard carbon films from the formation of sp^3 carbon (low sp^2/sp^3 ratio) (page 433, 1. Introduction and page 435, 3.3 Compressive stress of the film). Sheeja illustrates that a compressive stress of 10 GPa is obtained when a substrate bias of 85 V is utilized and the value is lower, approximately 1 GPa, when the substrate bias is higher, e.g., greater than 3000 V (page 435, 3.3 Compressive stress of the film and Figure 3).

11. Therefore, one of ordinary skill in the art would expect the high internal stress as taught by Hirano to inherently be compressive stress as evidenced by Sheeja. Hence the stress distribution as taught by Hirano is characterized in that the compressive stress at the surface of the coated film continuously increases from said surface toward an intermediate point located between said surface and the substrate/film interface and that the compressive stress attains a relative maximum point at the intermediate point.

12. It is well known in the art that accelerating ions toward the substrate and bombarding the surface induces compressive stress in a film, as it is considered atomic

peening action, as evidenced by Ohring (pages 184 and 748). Ohring also teaches that it is well known in the art that substrate biasing may be used to induce compressive stress in thin films and that by increasing the bias the internal stress of thin films may reverse from tensile to compressive (page 748, section 12.5.3.3 and page 749, table 12-2). Because of this, the teachings of Hirano as evidenced by Sheeja may seem counter intuitive. That compressive stress is induced in the film by "lowering" the acceleration voltage. However, Sheeja teaches the reason for this apparent anomaly. Sheeja explains that for carbon atoms, 85 V substrate bias is the optimum ion energy from a balance between the incident carbon ions having sufficient energy to penetrate the surface atomic layer, while minimizing the excess energy, which is dissipated during the growth. In the case of deposition at high substrate bias voltages, the excess energy may convert some of the sp^3 bonded to sp^2 bonded carbon atoms (page 435, 3.3 Compressive stress of the film). It is therefore considered well known in the art that for carbon films, the norm holds true for the acceleration of ions up to 85 V, but then the excess energy begins converting sp^3 bonded atoms to sp^2 bonded carbon atoms.

13. It should also be noted that when the substrate bias or acceleration voltage is mentioned without the use of a minus sign ("-"), there is not a different value attached. The values are taken simply as absolutes and are used to indicate the potential imparted to ions accelerating toward the surface to be coated.

14. It should be noted for convenience that as interpreted by the teachings of Hirano as evidenced by Sheeja, lower acceleration voltages for carbon films results in lower

sp^2/sp^3 ratios, which results in higher compressive stresses and that higher acceleration voltage for carbon films results in higher sp^2/sp^3 ratios and lower compressive stresses.

15. In regard to Claim 8, Hirano as evidenced by Sheeja and Ohring teaches an embodiment in which the strength distribution is characterized in that the compressive stress continuously decreases from the first intermediate point toward the bottom surface of the coated film (col. 13, Example 4, lines 19-33, Figure 13).

16. In regard to Claim 9, Hirano as evidenced by Sheeja and Ohring teaches forming a hard carbon film by starting with an acceleration voltage of 2000 V, then lowering the voltage to 200 V at the intermediate point and finally increasing the voltage back to 2000 V to finish the deposition.

17. Sheeja shows that a substrate bias of 85 V results in a compressive stress of about 10 GPa (page 435, 3.3 Compressive stress of the film, Figure 3) and that a substrate bias of greater than 3000 V is approximately 1 GPa (page 435, 3.3 Compressive stress of the film, Figure 3). It is noted that it is well known in the art that the "-" (minus sign) represents an internal compressive stress and differentiates from an internal tensile stress, "+" (plus sign), as evidenced by applicant (specification, page 16, lines 16-20). Therefore, because Sheeja has identified the stress as an internal compressive stress, the numerical values are interpreted absolute values.

18. Therefore it is expected by one of ordinary skill in the art that the compressive stress in the film of Hirano is in a range from at least -10 GPa to at most 1 GPa, as evidenced by Sheeja (Figure 3) because the acceleration voltages are within the range outlined by Sheeja.

19. In regard to Claim 10, Hirano as evidenced by Sheeja and Ohring teaches varying the acceleration voltage in a controlled fashion such that it starts at 2000 V, is varied in a constant manner to a minimum at 10 minutes and then increased back to the starting point of 2000 V (col. 13, Example 4, lines 19-25, Figure 13). The film forming time is shown to be 20 minutes (Figure 13). The intermediate point is interpreted as being located at a position distant from the top surface of the coated film by 50 % of the thickness of the film.

20. In regard to Claim 11, Hirano as evidenced by Sheeja and Ohring teaches an acceleration voltage of 2000 V during the formation of the film's surface. Because the acceleration voltage does not exceed 2000 V this is interpreted as the minimum of compressive stress, as evidenced by Sheeja (Figure 3).

21. In regard to Claim 12, Hirano as evidenced by Sheeja and Ohring teaches forming a compressive stress at the surface utilizing 2000 V and 200 V at the intermediate point. Sheeja shows that the compressive stress associated with 85 V is ~10 GPa and the compressive stress associate with 3000 V is ~1 GPa.

22. Hirano as evidenced by Sheeja and Ohring does not expressly teach the compressive stress at the surface of the film set to a value comparable to 25 to 95 % of the compressive stress at the intermediate point of the coated film.

23. However, with the curve indicated by the data of Sheeja, it would have been expected by one of ordinary skill in the art at the time of the invention that the compressive stress of Hirano as evidenced by Sheeja and Ohring would be greater than 1 GPa at the ending acceleration voltage of 2000 V and less than 10 GPa at the

intermediate acceleration voltage of 200 V. Therefore it would have been expected of one of ordinary skill in the art at the time of the invention to vary the compressive stress of the surface as taught by Hirano as evidenced by Sheeja and Ohring so that it is set to a value comparable to 25 to 95 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been expected to do this during optimization of the adhesion strength, wear resistance and hardness of the carbon film as demonstrated by Hirano (col. 2, lines 10-14).

24. In regard to Claim 13, Hirano as evidenced by Sheeja and Ohring does not expressly teach a compressive stress value for the surface of the film being set at a value comparable to 35 to 85 % of the compressive stress at the intermediate point of the coated film.

25. It would have been expected of one of ordinary skill in the art at the time of the invention to vary the compressive stress of the surface as taught by Hirano as evidenced by Sheeja so that it is set to a value comparable to 35 to 85 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been expected to do this during optimization of the adhesion strength, wear resistance and hardness of the carbon film as demonstrated by Hirano (col. 2, lines 10-14)..

26. In regard to Claim 14, Hirano as evidenced by Sheeja and Ohring teaches holding the acceleration voltage constant for the last minute of film growth after increasing the voltage from a minimum voltage (maximum compressive stress) at the intermediate point (col. 13, Example 4, lines 19-25, Figure 13). This is interpreted as

maintaining the compressive stress from the surface across a distance from the surface toward the intermediate point and thereafter the compressive stress continuously increases toward the intermediate point.

27. In regard to Claim 15, Hirano as evidenced by Sheeja and Ohring teaches holding the acceleration voltage constant for the first minute of film growth and then decreasing the voltage continuously to the intermediate point. This is interpreted (as evidenced by Sheeja and Ohring) as decreasing the compressive stress from a maximum at the intermediate point toward a second intermediate point located between the first intermediate point and the bottom surface of the film (col. 13, Example 4, lines 19-25, Figure 13).

28. In regard to Claim 16, Hirano as evidenced by Sheeja and Ohring teaches forming a hard carbon film by starting with an acceleration voltage of 2000 V, then lowering the voltage to 200 V at the intermediate point and finally increasing the voltage back to 2000 V to finish the deposition.

29. Sheeja shows that a substrate bias of 85 V results in a compressive stress of about 10 GPa (page 435, 3.3 Compressive stress of the film, Figure 3) and that a substrate bias of greater than 3000 V is approximately 1 GPa (page 435, 3.3 Compressive stress of the film, Figure 3).

30. Therefore it is expected by one of ordinary skill in the art that the compressive stress in the film of Hirano is in a range from at least -10 GPa to at most 1 GPa, as evidenced by Sheeja (Figure 3).

31. In regard to Claim 17, Hirano as evidenced by Sheeja and Ohring teaches varying the acceleration voltage in a controlled fashion such that it starts at 2000 V, is varied in a constant manner to a minimum at 10 minutes and then increased back to the starting point of 2000 V (col. 13, Example 4, lines 19-25, Figure 13). The film forming time is shown to be 20 minutes (Figure 13). The intermediate point is interpreted as being located at a position distant from the top surface of the coated film by 50 % of the thickness of the film.

32. In regard to Claim 18, Hirano as evidenced by Sheeja and Ohring teaches that the second intermediate point is formed after 1 minute of film growth and that the total film growth is 20 minutes. Therefore the second intermediate point is considered to be formed at 95 % of the thickness of the coated film.

33. In regard to Claim 19, Hirano as evidenced by Sheeja and Ohring teaches an acceleration voltage of 2000 V during the formation of the film's surface (col. 13, Example 4, lines 19-25, Figure 13). Because the acceleration voltage does not exceed 2000 V this is interpreted as the minimum of compressive stress, as evidenced by Sheeja (Figure 3).

34. In regard to Claim 20, Hirano as evidenced by Sheeja and Ohring teaches forming a compressive stress at the surface utilizing 2000 V and 200 V at the intermediate point. Sheeja shows that the compressive stress associated with 85 V is ~10 GPa and 3000 V is ~1 GPa.

35. Hirano as evidenced by Sheeja and Ohring does not expressly teach the compressive stress at the surface of the film set to a value comparable to 25 to 95 % of the compressive stress at the intermediate point of the coated film.

36. However, with the curve indicated by the data of Sheeja, it would have been expected by one of ordinary skill in the art at the time of the invention that the compressive stress of Hirano would be greater than 1 GPa at the ending acceleration voltage of 2000 V and less than 10 GPa at the intermediate acceleration voltage of 200 V. Therefore it would have been expected of one of ordinary skill in the art at the time of the invention to vary the compressive stress of the surface as taught by Hirano as evidenced by Sheeja and Ohring so that the compressive stress at the surface of the film is set to a value comparable to 25 to 95 % of the compressive stress at the first intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been expected to do this during optimization of the adhesion strength, wear resistance and hardness of the carbon film as demonstrated by Hirano (col. 2, lines 10-14).

37. In regard to Claim 21, Hirano as evidenced by Sheeja and Ohring does not expressly teach a compressive stress value for the surface of the film being set at a value comparable to 35 to 85 % of the compressive stress at the intermediate point of the coated film.

38. It would have been expected of one of ordinary skill in the art at the time of the invention to vary the compressive stress of the surface as taught by Hirano as evidenced by Sheeja and Ohring so that the compressive stress at the surface of the

film is set to a value comparable to 35 to 85 % of the compressive stress at the first intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been expected to do this during optimization of the adhesion strength, wear resistance and hardness of the carbon film as demonstrated by Hirano (col. 2, lines 10-14).

39. In regard to Claim 22, Hirano as evidenced by Sheeja and Ohring teaches holding the acceleration voltage of 2000 V constant during the final minute of film formation and the formation of the film's surface (col. 13, Example 4, Figure 13). Hirano teaches that the acceleration voltage was increased continuously from the first intermediate point (after 10 minutes of growth) (col. 13, Example 4, Figure 13). This is interpreted as maintaining a compressive stress from the surface of the film across a distance and then increasing the compressive stress continuously to the first intermediate point.

Claim Rejections - 35 USC § 103

40. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

41. The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

42. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

43. Claims 2-32 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 6,066,399 to Hirano et al., hereinafter referred to as “Hirano”, in view of Sheeja et al., *Tribological properties and adhesive strength of DLC coatings prepared under different substrate bias voltages*, Wear 249 (2001), pg. 433-439, hereinafter referred to as “Sheeja”, as evidenced by <u>Materials Science of Thin Films, Deposition and Structure</u>, Milton Ohring, 2nd Ed., 2004, hereinafter referred to as "Ohring”.

44. The teachings of Hirano as evidenced by Sheeja and Ohring as mentioned above in the rejection of Claim 1, section 102 rejections, are relied upon.

45. In regard to Claim 2, Hirano teaches an embodiment (col. 13, Example 4) in which the acceleration voltage is at 200 V for the intermediate point (high compressive stress, as noted above) of film growth and then increased to 2000 V (low compressive stress, as noted above) and held there for the last minute of the film formation. Hirano

teaches that the high sp^2/sp^3 ratio formed at the surface results in a smooth surface (col. 9, lines 54-60). Therefore one of ordinary skill in the art at the time of the invention would have expected the compressive stress to be at a minimum at the surface of the carbon film and increase continuously to the intermediate point of the film. Hirano also teaches the ability to hold the acceleration voltage constant during the film growth resulting in a continuous sp^2/sp^3 ratio (col. 11, Example 2, lines 54-57, Figure 10).

46. Hirano does not teach a minimum compressive stress at the surface of the film, obtaining a maximum compressive stress at an intermediate point in the film and then maintaining a constant value from said first intermediate point to the bottom surface of the coated film.

47. Sheeja teaches that forming the carbon film with a high substrate bias, i.e., a high sp^2/sp^3 ratio, results in a slightly lower coefficient of friction (page 432, Figure 7) and that this may be desirable because the graphitic structure of the sp^2 carbon acts as a solid lubricant on the surface of the film (page 438, 4. Discussion). Sheeja also teaches that a low sp^2/sp^3 ratio film, formed with a lower substrate bias, results in a harder film with a much lower wear rate (page 432, Figure 8). Sheeja further teaches that one of ordinary skill in the art at the time of the invention would be motivated to optimize the substrate bias during the formation of the hard film (page 438, 5. Conclusion). Sheeja teaches forming the films at constant substrate biases (page 434, 2.1 Preparation of DLC film).

48. Therefore it would have been obvious one of ordinary skill in the art at the time of the invention to modify the sp^2/sp^3 ratio of Hirano via the acceleration voltages of

Sheeja, as evidenced by Ohring so that the minimum compressive stress is present on the surface of the film, i.e., the sp^2/sp^3 ratio is high, and that the compressive stress remain constant from the intermediate point to the substrate. One of ordinary skill in the art at the time would have been motivated to do this in order to provide a low wear rate film as taught by Sheeja and to provide a smooth surface that can act as a solid lubricant as taught by Hirano.

49. In regard to Claim 3, Sheeja further teaches that a substrate bias of 85 V results in a compressive stress of about 10 GPa (page 435, 3.3 Compressive stress of the film, Figure 3) and that a substrate bias of greater than 3000 V is approximately 1 GPa (page 435, 3.3 Compressive stress of the film, Figure 3). It is noted that it is well known in the art that the "-" (minus sign) represents an internal compressive stress and differentiates from an internal tensile stress, "+" (plus sign), as evidenced by applicant (specification, page 16, lines 16-20).

50. Therefore it is expected by one of ordinary skill in the art that the compressive stress at any point in the film of Hirano in view of Sheeja, as evidenced by Ohring would be in a range from at least -10 GPa to at most 1 GPa, as shown in Sheeja (Figure 3).

51. In regard to Claim 4, Hirano in view of Sheeja, as evidenced by Ohring teaches varying the acceleration voltage in a controlled fashion such that it starts at 2000 V, is varied in a constant manner to a minimum at 10 minutes and then increased back to the starting point of 2000 V (col. 13, Example 4, lines 19-25, Figure 13). The film forming time is shown to be 20 minutes (Figure 13). The intermediate point is interpreted as

being located at a position distant from the top surface of the coated film by 50 % of the thickness of the film.

52. In regard to Claim 5, Hirano in view of Sheeja as evidenced by Ohring teaches forming a compressive stress at the surface utilizing 2000 V and 200 V at the intermediate point. Sheeja shows that the compressive stress associated with 85 V is ~10 GPa and 3000 V is ~1 GPa.

53. Hirano in view of Sheeja as evidenced by Ohring does not expressly teach the compressive stress at the surface of the film set to a value comparable to 25 to 95 % of the compressive stress at the intermediate point of the coated film.

54. However, based on the curve indicated by the data of Sheeja (Figure 3), it would have been expected by one of ordinary skill in the art at the time of the invention, that the compressive stress of Hirano would be greater than 1 GPa at the ending acceleration voltage of 2000 V and less than 10 GPa at the intermediate acceleration voltage of 200 V. It also would be expected of one of ordinary skill in the art to modify the ratio of compressive stress at the surface and said intermediate point for the purpose of increasing adhesion between layers/phases and preventing delamination of the film.

55. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of the surface as taught by Hirano via the optimization as taught by Sheeja as evidenced by Ohring to vary the compressive stress value of the surface so that it was set to 25 to 95 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of

the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

56. In regard to Claim 6, Hirano in view of Sheeja as evidenced by Ohring does not expressly teach a compressive stress value for the surface of the film being set at a value comparable to 35 to 85 % of the compressive stress at the intermediate point of the coated film. However, it would be expected of one of ordinary skill in the art to modify the ratio of compressive stress at the surface and said intermediate point for the purpose of increasing adhesion between layers/phases and preventing delamination of the film.

57. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of the surface as taught by Hirano via the optimization as taught by Sheeja to vary the compressive stress value of the surface so that it was set to 35 to 85 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

58. In regard to Claim 7, Hirano in view of Sheeja as evidenced by Ohring teaches holding the acceleration voltage constant for the last minute of film growth after increasing the voltage from a maximum compressive stress at the intermediate point (col. 13, Example 4, lines 19-25, Figure 13). This is interpreted as maintaining the compressive stress across a distance from the surface of the film and then increasing the compressive to a first intermediate point.

59. In regard to Claims 8-22, in the event that the claims are interpreted more narrowly and that the decreasing of the compressive stress from the first intermediate point continuously to the bottom surface of the film is considered not to be met due to the constant acceleration voltage during the first minute of film formation, the following would have been obvious to one of ordinary skill in the art at the time of the invention.

60. In regard to Claim 8, Hirano in view of Sheeja as evidenced by Ohring does not expressly teach continuously decreasing the compressive stress from said first intermediate point to the bottom surface of the film.

61. Sheeja teaches growing the carbon films at a constant substrate bias. Sheeja teaches that films formed with a high substrate bias have an increased intermixed layer with the substrate and therefore have a higher critical load (increased adhesion to the substrate) (page 437, Figure 9 and page 438 3.6 Adhesion of the coating to the substrate). Sheeja also teaches that one of ordinary skill in the art would be motivated to vary the conditions of substrate bias for the purpose of optimizing the coated film (page 438, 5. Conclusion).

62. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the coated film of Hirano in view of Sheeja as evidenced by Ohring so that the acceleration voltage was high during the beginning of film growth, i.e., the compressive stress is low, and then lowered continuously, i.e., the compressive stress is continuously increased, from the bottom surface of the film to the first intermediate point. One of ordinary skill in the art at the time of the invention would have been motivated to do this for the purpose of providing increased adhesion to the

substrate by a high substrate bias and an increased wear resistance by a lower substrate bias as taught by Sheeja.

63. In regard to Claim 9, Hirano in view of Sheeja as evidenced by Ohring teaches forming a hard carbon film by starting with an acceleration voltage of 2000 V, then lowering the voltage to 200 V at the intermediate point and finally increasing the voltage back to 2000 V to finish the deposition.

64. Sheeja shows that a substrate bias of 85 V results in a compressive stress of about 10 GPa (page 435, 3.3 Compressive stress of the film, Figure 3) and that a substrate bias of greater than 3000 V is approximately 1 GPa (page 435, 3.3 Compressive stress of the film, Figure 3).

65. In the event that it is not expected by one of ordinary skill in the art that the compressive stress in the film of Hirano be in a range from at least -10 GPa to at most 1 GPa, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of Hirano by the optimization of Sheeja, as evidenced by Ohring as noted above in the section 103 rejections, rejection of Claim 8. One of ordinary skill in the art at the time of the invention would have been motivated to do this for the purpose of optimizing the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

66. In regard to Claim 10, Hirano in view of Sheeja as evidenced by Ohring teaches varying the acceleration voltage in a controlled fashion such that it starts at 2000 V, is varied in a constant manner to a minimum at 10 minutes and then increased back to the starting point of 2000 V (col. 13, Example 4, lines 19-25, Figure 13). The film forming

time is shown to be 20 minutes (Figure 13). The intermediate point is interpreted as being located at a position distant from the top surface of the coated film by 50 % of the thickness of the film.

67. In regard to Claim 11, Hirano in view of Sheeja as evidenced by Ohring teaches an acceleration voltage of 2000 V during the formation of the film's surface. Because the acceleration voltage does not exceed 2000 V this is interpreted as the minimum of compressive stress, as evidenced by Sheeja (Figure 3).

68. In regard to Claim 12, Hirano in view of Sheeja as evidenced by Ohring teaches forming a compressive stress at the surface utilizing 2000 V and 200 V at the intermediate point. Sheeja shows that the compressive stress associated with 85 V is ~10 GPa and 3000 V is ~1 GPa.

69. Hirano in view of Sheeja as evidenced by Ohring does not expressly teach the compressive stress at the surface of the film set to a value comparable to 25 to 95 % of the compressive stress at the intermediate point of the coated film.

70. However, with the curve indicated by the data of Sheeja, it would have been expected by one of ordinary skill in the art at the time of the invention that the compressive stress of Hirano would be greater than 1 GPa at the ending acceleration voltage of 2000 V and less than 10 GPa at the intermediate acceleration voltage of 200 V. It would be expected of one of ordinary skill in the art to modify the ratio of compressive stress at the surface and said intermediate point for the purpose of increasing adhesion between layers/phases and preventing delamination of the film.

71. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of the surface as taught by Hirano via the optimization as taught by Sheeja to vary the compressive stress value of the surface so that it was set to 25 to 95 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

72. In regard to Claim 13, Hirano in view of Sheeja as evidenced by Ohring does not expressly teach a compressive stress value for the surface of the film being set at a value comparable to 35 to 85 % of the compressive stress at the intermediate point of the coated film. However, it would be expected of one of ordinary skill in the art to modify the ratio of compressive stress at the surface and said intermediate point for the purpose of increasing adhesion between layers/phases and preventing delamination of the film.

73. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of the surface as taught by Hirano via the optimization as taught by Sheeja as evidenced by Ohring to vary the compressive stress value of the surface so that it was set to 35 to 85 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

74. In regard to Claim 14, Hirano in view of Sheeja as evidenced by Ohring teaches holding the acceleration voltage constant for the last minute of film growth after increasing the voltage from a minimum voltage (maximum compressive stress) at the intermediate point (col. 13, Example 4, lines 19-25, Figure 13). This is interpreted as maintaining the compressive stress from the surface across a distance from the surface toward the intermediate point and thereafter the compressive stress continuously increases toward the intermediate point.

75. In regard to Claim 15, Hirano in view of Sheeja as evidenced by Ohring teaches holding the acceleration voltage constant for the first minute of film growth and then decreasing the voltage continuously to the intermediate point. This is interpreted as decreasing the compressive stress from a maximum at the intermediate point toward a second intermediate point located between the first intermediate point and the bottom surface of the film (col. 13, Example 4, lines 19-25, Figure 13).

76. In regard to Claim 16, Hirano in view of Sheeja as evidenced by Ohring teaches forming a hard carbon film by starting with an acceleration voltage of 2000 V, then lowering the voltage to 200 V at the intermediate point and finally increasing the voltage back to 2000 V to finish the deposition.

77. Sheeja teaches that a substrate bias of 85 V results in a compressive stress of about 10 GPa (page 435, 3.3 Compressive stress of the film, Figure 3) and that a substrate bias of greater than 3000 V is approximately 1 GPa (page 435, 3.3 Compressive stress of the film, Figure 3).

78. Therefore it would have been expected that the compressive stress in the film of Hirano is in a range from at least -10 GPa to at most 1 GPa, as evidenced by Sheeja (Figure 3).

79. In regard to Claim 17, Hirano in view of Sheeja as evidenced by Ohring teaches varying the acceleration voltage in a controlled fashion such that it starts at 2000 V, is varied in a constant manner to a minimum at 10 minutes and then increased back to the starting point of 2000 V (col. 13, Example 4, lines 19-25, Figure 13). The film forming time is shown to be 20 minutes (Figure 13). The intermediate point is interpreted as being located at a position distant from the top surface of the coated film by 50 % of the thickness of the film.

80. In regard to Claim 18, Hirano in view of Sheeja as evidenced by Ohring teaches that the second intermediate point is formed after 1 minute of film growth and that the total film growth is 20 minutes. Therefore the second intermediate point is considered to be formed at 95 % of the thickness of the coated film.

81. In regard to Claim 19, Hirano in view of Sheeja as evidenced by Ohring teaches an acceleration voltage of 2000 V during the formation of the film's surface (col. 13, Example 4, lines 19-25, Figure 13). Because the acceleration voltage does not exceed 2000 V this is interpreted as the minimum of compressive stress, as evidenced by Sheeja (Figure 3).

82. In regard to Claim 20, Hirano in view of Sheeja as evidenced by Ohring teaches forming a compressive stress at the surface utilizing 2000 V and 200 V at the

intermediate point. Sheeja shows that the compressive stress associated with 85 V is ~10 GPa and 3000 V is ~1 GPa.

83. Hirano in view of Sheeja as evidenced by Ohring does not expressly teach the compressive stress at the surface of the film set to a value comparable to 25 to 95 % of the compressive stress at the intermediate point of the coated film.

84. However, with the curve indicated by the data of Sheeja, it would have been expected by one of ordinary skill in the art at the time of the invention that the compressive stress of Hirano would be greater than 1 GPa at the ending acceleration voltage of 2000 V and less than 10 GPa at the intermediate acceleration voltage of 200 V. It also would be expected of one of ordinary skill in the art to modify the ratio of compressive stress at the surface and said intermediate point for the purpose of increasing adhesion between layers/phases and preventing delamination of the film.

85. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of the surface as taught by Hirano via the optimization as taught by Sheeja to vary the compressive stress value of the surface so that it was set to 25 to 95 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

86. In regard to Claim 21, Hirano in view of Sheeja as evidenced by Ohring does not expressly teach a compressive stress value for the surface of the film being set at a value comparable to 35 to 85 % of the compressive stress at the intermediate point of

the coated film. However, it would be expected of one of ordinary skill in the art to modify the ratio of compressive stress at the surface and said intermediate point for the purpose of increasing adhesion between layers/phases and preventing delamination of the film.

87. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the compressive stress of the surface as taught by Hirano via the optimization as taught by Sheeja to vary the compressive stress value of the surface so that it was set to 35 to 85 % of the compressive stress at the intermediate point of the coated film. One of ordinary skill in the art at the time of the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

88. In regard to Claim 22, Hirano in view of Sheeja as evidenced by Ohring teaches holding the acceleration voltage of 2000 V constant during the final minute of film formation and the formation of the film's surface (col. 13, Example 4, Figure 13). Hirano teaches that the acceleration voltage was increased continuously from the first intermediate point (after 10 minutes of growth) (col. 13, Example 4, Figure 13). This is interpreted as maintaining a compressive stress from the surface of the film across a distance and then increasing the compressive stress continuously to the first intermediate point.

89. In regard to Claims 23-25, Hirano in view of Sheeja as evidenced by Ohring teaches said strength distribution is characterized in that said compressive stress continuously decreases from said first intermediate point toward a second intermediate

point located between said first intermediate point and said bottom surface of said coated film and attains a relative minimum point at said second intermediate point as noted above.

90. Hirano teaches a specific embodiment of having a continuously decreasing compressive stress from the top surface of the film to the bottom surface (substrate side) of the film (col. 10, Example 1, Figure 8). Hirano also teaches a constant compressive stress throughout the film to just above the bottom surface (substrate side) of the film (col. 11, Example 2, Figure 10). Hirano teaches a continuous increase in compressive stress from the top surface of the film to a first intermediate point in the film (maximum compressive stress) and then decreasing the compressive stress toward the bottom surface of the film (col. 13, Example 4, Figure 13). Finally, Hirano also teaches the stepwise increase of the compressive stress from the top surface of the film to an intermediate point in the film and then the stepwise decrease from the intermediate point to the bottom surface of the film (col. 13, Example 5, Figure 15). Hirano teaches a single growth time of 20 minutes.

91. However, the steps of the increasing compressive stress, i.e., decreasing substrate bias, taught by Hirano may be interpreted as alternating and repeating manner of relative minimums and maximums in the film (formed at 4, 8, 12 and 16 minutes).

92. Hirano in view of Sheeja as evidenced by Ohring does not expressly teach the formation of a maximum compressive stress at a first intermediate point, decreasing the compressive stress to a minimum at a second intermediate point, and then having a

strength distribution with one or more relative maximum and minimums between the second intermediate point and the substrate.

93. Sheeja teaches that one of ordinary skill in the art would be motivated to optimize the thickness and other parameters, such as substrate bias during the film formation (page 438, 5. Conclusion).

94. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Hirano via the varying thickness of Sheeja and to modify the film of Hirano in view of Sheeja to include multiple relative minimums and maximums in the film with vary thicknesses. One of ordinary skill in the art at the time of the invention would have been motivated to do this to optimize the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja. It would be expected that modifying the compressive stress of the film at varying intermediate points in the film would result in increasing adhesion between layers/phases and preventing delamination of the film while providing a low wear rate material as evidenced by Sheeja.

95. In regard to Claim 26, Hirano in view of Sheeja as evidenced by Ohring teaches forming a hard carbon film by starting with an acceleration voltage of 2000 V, then lowering the voltage to 200 V at the intermediate point and finally increasing the voltage back to 2000 V to finish the deposition. Hirano also teaches forming multiple steps of stress in the carbon film (col. 13, Example 5, Figure 15).

96. Sheeja further teaches that a substrate bias of 85 V results in a compressive stress of about 10 GPa (page 435, 3.3 Compressive stress of the film, Figure 3) and

that a substrate bias of greater than 3000 V is approximately 1 GPa (page 435, 3.3 Compressive stress of the film, Figure 3).

97. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the multiple relative minimums and maximums of compressive stress of Hirano in view of Sheeja as evidenced by Ohring by the optimization of compressive stress of Sheeja and that the compressive stress is in a range of 10 GPa to 1 GPa. One of ordinary skill in the art at the time of the invention would have been motivated to do this for the purpose of optimizing the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja.

98. In regard to Claim 27, Hirano in view of Sheeja as evidenced by Ohring further teaches the formation of stepwise increases in the compressive stress from the surface of the carbon film to the intermediate point of the film and then the stepwise decrease of the compressive stress from the intermediate point to the bottom surface of the film (col. 13, Example 5, Figure 15). The first step point below the surface of the film is for the final 4 minutes of growth (col. 13, lines 55-61, Figure 15). This is interpreted as being located at 20 % of the film's thickness.

99. Hirano in view of Sheeja as evidenced by Ohring does not expressly teach having a first intermediate point with a maximum compressive stress by at least 0.1 % to at most 40 % of the thickness of the said coated film.

100. However, because Hirano teaches the ability to obtain a relative maximum located at 20 % of the film's thickness, it would have been obvious to one of ordinary skill in the art at the time of the invention to have a first intermediate point of the multiple

relative maximums of compressive stress, as noted above, at 20 % of the film's thickness distant from the top surface. One of ordinary skill in the art at the time of the invention would have been motivated to do this for the purpose of optimizing the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja. It would be expected that modifying the compressive stress of the film at varying intermediate points in the film would result in increasing adhesion between layers/phases and preventing delamination of the film while providing a low wear rate material as evidenced by Sheeja.

101. In regard to Claim 28, Hirano in view of Sheeja as evidenced by Ohring teaches the formation of stepwise increases in the compressive stress from the surface of the carbon film to the intermediate point of the film and then the stepwise decrease of the compressive stress from the intermediate point to the bottom surface of the film (col. 13, Example 5, Figure 15). The first step point below the surface of the film is for the final 4 minutes of growth and the second step point below the surface of the film is at 12 minutes into the growth (col. 13, lines 55-61, Figure 15). This is interpreted as being located at 40 % of the film’s thickness distant from the top surface, as noted above in the 103 rejection of Claim 27.

102. Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to have a first intermediate point of the multiple relative maximums of compressive stress as noted above at 20 % of the film's thickness distant from the top surface and said second intermediate point at 40 % of the film’s thickness distant from the top surface. One of ordinary skill in the art at the time of the invention would have

been motivated to do this for the purpose of optimizing the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja. It would be expected that modifying the compressive stress of the film at varying intermediate points in the film would result in increasing adhesion between layers/phases and preventing delamination of the film while providing a low wear rate material as evidenced by Sheeja.

103. In regard to Claim 29, Hirano in view of Sheeja as evidenced by Ohring teaches a minimum of compressive stress at the surface of the film.

104. In regard to Claim 30, Hirano in view of Sheeja as evidenced by Ohring as noted above teaches multiple relative minimums and maximums in the film with vary thicknesses.

105. Hirano further teaches a maximum of compressive stress at an intermediate point (col. 13, Example 4, Figure 13) and a stepwise decrease from an intermediate maximum to the substrate (col. 13, Example 4, Figure 15). Hirano teaches that the step from the intermediate point with a maximum compressive stress to the next point in the stepwise decrease of compressive stress to the substrate is from 200 V to 1000 V.

106. Sheeja teaches that a compressive stress of 10 GPa is introduced with a substrate bias of 85 V while a substrate bias of 3000 V introduced a 1 GPa compressive stress.

107. Hirano in view of Sheeja as evidenced by Ohring does not expressly teach said compressive stress at said second intermediate point of said coated film is set to a

value comparable to 10 to 80 % of the compressive stress at said first intermediate point of said coated film.

108. However, a step corresponding to 3000 V to 85 V would be expected to produce a second intermediate point with approximately 10 % of the compressive stress of the first intermediate point. Therefore it would be expected by one of ordinary skill in the art that a step corresponding to 200 V and 1000 V would produce a second intermediate point with at least 10 % of the compressive stress but not more than 80 % of the compressive stress of the first intermediate point.

109. It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the multiple steps of Hirano in view of Sheeja as evidenced by Ohring via the optimization of Sheeja for the purpose of creating multiple relative maximums and minimums in the carbon film. One of ordinary skill in the art would have been motivated to do this for the purpose of optimizing the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja. It would be expected that modifying the compressive stress of the film at varying intermediate points in the film would result in increasing adhesion between layers/phases and preventing delamination of the film while providing a low wear rate material as evidenced by Sheeja.

110. In regard to Claim 31, Hirano in view of Sheeja as evidenced by Ohring teaches varying the compressive stress in a stepwise manner throughout the coated film. Sheeja teaches that one of ordinary skill in the art would be motivated to optimize the film by varying the substrate bias and film thicknesses (page 438, 5. Conclusion).

111. Hirano in view of Sheeja as evidenced by Ohring does not teach said compressive stress at said second intermediate point of said coated film is set to a value comparable to 20 to 60 % of the compressive stress at said fist intermediate point of said coated film.

112. However, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify compressive stress of said second intermediate point so that it was set to a value comparable to 20 to 60 % of the compressive stress of said first intermediate point of the coated film for the purpose of optimizing the adhesion strength, wear resistance and hardness of the carbon film as taught by Sheeja. It would be expected that modifying the compressive stress of the film at varying intermediate points in the film would result in increasing adhesion between layers/phases and preventing delamination of the film while providing a low wear rate material as evidenced by Sheeja.

113. In regard to Claim 32, Hirano in view of Sheeja as evidenced by Ohring teaches holding the acceleration voltage constant for the last minute of film growth after increasing the voltage from a minimum voltage (maximum compressive stress) at the intermediate point (col. 13, Example 4, lines 19-25, Figure 13). This is interpreted as maintaining the compressive stress from the surface across a distance from the surface toward the intermediate point and thereafter the compressive stress continuously increases toward the intermediate point.

Conclusion

114. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ronald A. Quinlan whose telephone number is (571) 270-1149. The examiner can normally be reached on Monday to Thursday from 6:30am-4:30pm Eastern.

115. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael LaVilla can be reached on (571) 272-1539. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

116. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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